FARMERS' BULLETIN 1027
United States Department of Agriculture

STRAWBERRY CULTURE

WESTERN · UNITED · STATES

THIS BULLETIN applies to that part of the United States in which ordinary farm crops are grown largely under irrigation.

It describes methods practiced in the more important commercial strawberry-growing districts in the irrigated regions of the West; it aims to aid those familiar only with local and perhaps unsatisfactory methods, as well as inexperienced prospective growers.

The fundamental principles of the irrigation of strawberries are substantially the same as those which apply in the growing of other crops. Details of operation must necessarily be governed largely by the character of the crop grown.

Since strawberries in the humid regions frequently suffer from drought, which causes heavy losses in the developing fruit, the information may prove suggestive to many growers in those localities who could install an irrigation system at small expense.

Detailed information is also given as to soils and their preparation, different training systems, propagation, planting, culture, the leading varieties, harvesting, and shipping.

Methods of using surplus strawberries for preserves and jams, for canning, and for flavoring for various purposes are given.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. April, 1919

STRAWBERRY CULTURE: WESTERN UNITED STATES.

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REGION TO WHICH THIS BULLETIN APPLIES.

STRAWBERRIES must be grown largely under irrigation to make crop production reasonably sure in the area to which this bulletin applies. In addition there is included a comparatively small area in the States of Washington, Oregon, and California where the rainfall is sufficient to raise strawberries without irrigation. (See initial diagram.)

Along the Pacific coast, and to a slight extent elsewhere in this area, strawberries are grown for the general markets of the Western and Middle-Western States. The points from which shipments originate in the United States are shown on the map in figure 1. It should be noted that the largest centers of commercial strawberry production in the part of the country here considered are located in Los Angeles County, in southern California; in the Santa Clara Valley, south of San Francisco; and at Hood River, Oreg., with a considerable number of carloads produced in other localities.

The practices followed in growing strawberries in the semiarid regions of the West are quite different from those in the Eastern States.[1]

FACTORS LIMITING STRAWBERRY PRODUCTION.

Several factors limit strawberry production in the Western States, namely, moisture, alkali, nematodes, accessibility to markets, transportation facilities, and the labor supply.

Moisture supply.—In nearly all that part of the United States discussed in this bulletin the moisture supply, either throughout the entire year or for certain long periods, is below what is needed for the

FIG. 1.—Outline map showing the average number of carload shipments of strawberries for 1914 and 1915 in different parts of the United States, together with the approximate shipping season for each district. The dots represent 10 carloads each except where they occur singly, when they may represent any number of carloads up to 10. (Adapted from data in Department of Agriculture Bulletins 237 and 477.)

production of strawberries. Because of this, strawberries can be grown commercially only where water for irrigation can be supplied when it is needed by the plants.

Alkaline soil.—In many parts of the area to which this bulletin applies, the soils contain alkali, and alkaline salts are brought to the surface in such quantities as a result of irrigation that the strawberry plants are injured or even killed outright. Usually the first indication of alkali injury is the yellowing of the leaves in the lower spots in the field. In selecting a site for a strawberry field, those places where the soils are known to contain alkali should be avoided.

[1] See Farmers' Bulletin 1026, "Strawberry Culture: South Atlantic and Gulf Coast Regions"; 1028, "Strawberry Culture: Eastern United States"; and 1043, "Strawberry Varieties in the United States." These may be obtained free, on request to the Secretary of Agriculture.

Nematodes.—These parasites are known also as eelworms and gallworms. Their effect, which is usually manifest first on the roots, is commonly called root-knot because of the knotlike enlargements produced on the roots at the points of infestation.

These nematodes are very small, being only about one-sixtieth to one-twentieth of an inch long. They occur rather widely in soils where the climate is so mild throughout the year that the ground rarely freezes more than a very few inches deep or not at all.

Strawberry plants are quite susceptible to this parasite, and heavy losses occur in some localities when they are planted on infested soil.

FIG. 2.—A field of strawberries badly infested with nematodes and suffering on account of lack of moisture. Many plants are dead, leaving blank spaces, and the root systems of others are weakened by the nematodes. The plants quickly die when moisture is lacking.

The growing of strawberries has been abandoned in some areas because of the seriousness of this trouble.

When the roots of a plant become badly infested, the foliage assumes an unhealthy appearance and may wilt in hot weather, finally dying. In less severe infestations the plants, in case they are fruiting, may become so depleted that the crop is of little or no value. A strawberry field badly infested with nematodes is shown in figure 2.

Accessibility of markets and facilities for transportation.—There is close relationship between transportation facilities and the accessibility of markets. It is obvious that a community provided with good railroad service, refrigerator cars, and icing stations is in a very much better position with reference to the delivery of strawberries in

good condition to distant markets than one located perhaps only a comparatively few miles from a large center of population but with no readily available means of transportation.

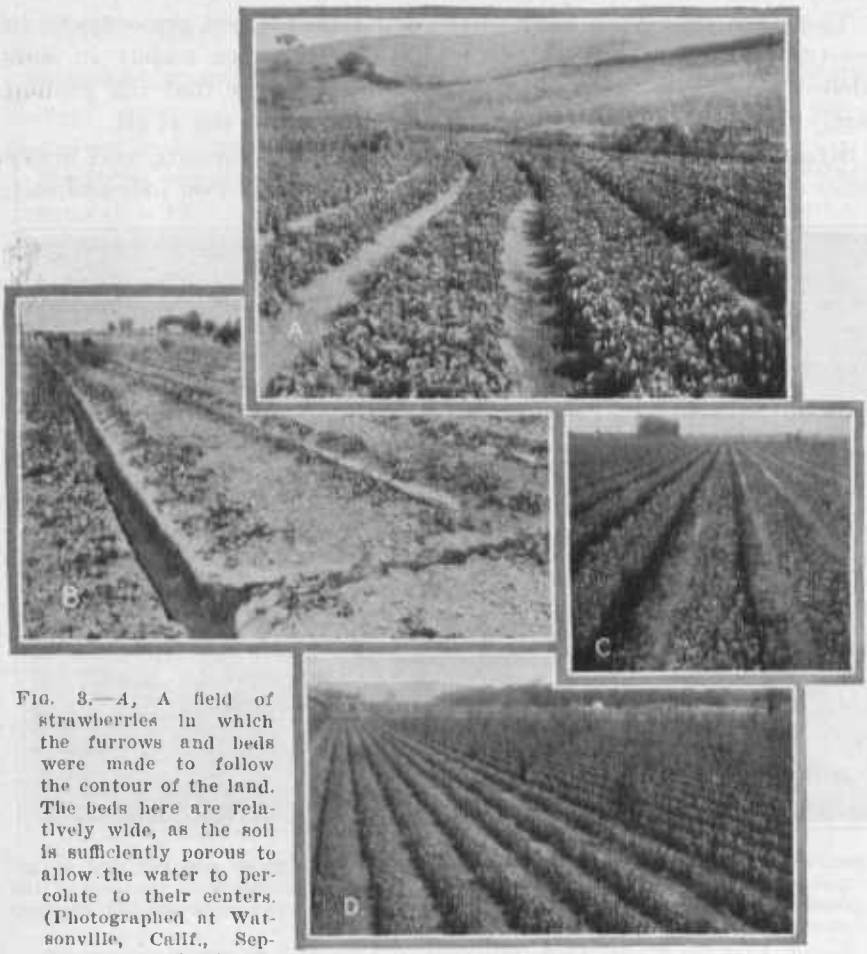

FIG. 3.—*A*, A field of strawberries in which the furrows and beds were made to follow the contour of the land. The beds here are relatively wide, as the soil is sufficiently porous to allow the water to percolate to their centers. (Photographed at Watsonville, Calif., September 5, 1916.) *B*, Strawberries under surface irrigation. The ditches are 8 feet apart and about 12 inches deep. The beds were made before the plants were set. A row of plants is set on each side of the ditch and the new plants are allowed to make a matted row. (Photographed at Florin, Calif., August, 1916.) *C*, The furrows here were made before the plants were set. The beds are about 6 inches higher than the furrows and are 3 feet wide from center to center. The two rows on each bed are 12 inches apart and the plants in the row 6 inches apart. (Photographed at Moneta, Calif., September 9, 1916.) *D*, The furrows in this field of strawberries are only 3 or 4 inches below the beds on which the plants were set in hills 18 inches apart; the beds are about 2 feet from center to center. (Photographed at Irvington, Calif., September 2, 1916.)

Where strawberries are grown near the larger towns and cities, the local demands may be depended on to absorb a supply of fruit commensurate with their population. The improved highways that

have been developed in many States and the use of auto trucks have materially increased the distances over which fruit may be transported by private conveyances to local markets.

On the other hand, many locations admirably adapted to strawberry growing, so far as natural advantages are concerned, are quite

FIG. 4.—*A*, A field of strawberries planted without furrows, to be grown in hills. The rows are 32 inches and the plants in the rows 12 inches apart. Shallow furrows will be made between the rows when the plants need irrigation. (Photographed at Hood River, Oreg., July 30, 1916.) *B*, Rows of young strawberries growing in hills. The plants were set, after the first rain in November, 1 foot apart in rows 3½ feet distant, and all runners were removed as they appeared. (Photographed at Santa Rosa, Calif., August 31, 1916.)

impossible from a commercial standpoint, because they are without the necessary means of transportation by which the fruit can be delivered to the markets in good condition.

The accessibilty of supplies, such as berry boxes and crates, is closely related to the available transportation service. In this respect, as well as with regard to the advantages of shipping in carloads, a location for commercial growing where there are large straw-

berry interests is usually much to be preferred to one in which such community interests do not exist. This is not the case, however, where the fruit is grown for local markets and where carload shipments do not need to be considered. The one who supplies a local market may be fortunate if there is but little competition in the production of his commodity in the community.

Thus, the prospective strawberry grower must take into account very fully the means of getting his fruit to the consumer if he is to avoid disaster, even after his crop has been produced successfully.

FIG. 5.—*A*, Strawberries set in double rows under the hill system. The plants are 8 inches apart and the two rows 14 inches apart. The furrow between the beds is 28 inches wide. Covered carriers for receiving the picked fruit are shown. (Photographed at Santa Clara, Calif., September 4, 1916.) *B*, Strawberries growing in spaced matted rows on raised beds. Note the cracks in the soil along the furrows. (Photographed at Watsonville, Calif., September 6, 1916.)

Labor supply.—The care of a strawberry plantation in irrigated regions ordinarily takes the time of one man for each acre up to the picking season, and one man for each 4 or 5 acres under intensive cultivation in nonirrigated regions. During the harvesting season additional help is necessary. This varies with the size of the crop, but usually from 6 to 10 pickers per acre are needed. In some localities growers have found difficulty in securing labor to pick their crop, and have encountered severe losses on this account. Therefore, before starting in the production of strawberries on any large scale, an adequate supply of labor from year to year should be assured.

PREPARATION OF THE SOIL.

The preparation of land for the planting of strawberries should be complete and thorough. Any neglect or failure in this respect

before setting the plants is likely to prove costly later. If the soil is not abundantly supplied with humus, it should be supplied before planting, either by making adequately heavy applications of manure or, by the growing and turning under of one or more green-manure crops, preferably a legume, such as clover, cowpeas, or some other crop adapted to the region.

Two-year preparation of sod land.—Thus the preparation of the soil may need to begin the season before, or perhaps two seasons before the plants are set. The latter is true of sod land,

FIG. 6.—*A*, Bundles of plants of the Klondike and Dunlap strawberries. Note that the Dunlap plants do not grow as large as those of the Klondike. *B*, Heeling in plants until it is convenient to set them in the field. The bundles are opened, each plant laid by itself with the crown even with the surface of the ground, and the moist soil packed firmly against the roots.

particularly in the regions where white grubs are serious. These grubs are the larvæ of May beetles, or June bugs, which frequently are abundant in sod land, where the eggs are commonly laid. If strawberries are planted on land infested with large numbers of white grubs a heavy loss of plants on account of the roots being eaten by the grubs may be expected. Since white grubs remain in the soil in the worm or larval stage for about two years and, further, as the grass roots in the sod might interfere with the suitable preparation of the soil, sod

land usually should be devoted to hoed crops for two seasons before it is planted to strawberries. During this period, by proper management, the humus content can be renewed if desirable.

Freeing soil of nematodes.—Again, the seriousness of nematodes in some sections and under some conditions has been mentioned. Because of the certainty of the heavy loss of plants from infestation by this parasite, soil known to be seriously

FIG. 7.—*A*, Punch and tongs commonly used in setting sweet-potato plants, which may also be used advantageously in setting strawberry plants. A hole is made with the punch, and the plant is picked up and placed in the hole with the tongs. The punch and tongs are especially useful in mellow soils. *B*, Strawberry plants set at proper and improper depths in the soil. The one at the left is too deep, the center one is properly planted, while the one at the right is not deep enough. *C*, Shows a fertilizer sack used in dropping the plants. A hole is cut for the head, a slit is made across one side, and the plants are placed in the bottom of the sack. This protects them from the sun and wind.

infested with nematodes should not be set to strawberries.

The soil can be freed of nematodes in the course of two to three years by the starvation process, which consists in keeping the land entirely bare of vegetation for two (but preferably for three) years, or growing on it only such plants as are immune or very highly resistant to them.

Unfortunately, many of the most valuable farm crops, and some kinds of fruit trees, including peaches and figs, are susceptible to nematodes, but some crops are immune or nearly so, and these may be used on nematode-infested land with the same starvation effect as if the land was kept free of vegetation. Some of the immune, or practically immune, crops are corn, sorghum, winter oats, rye, millet, wheat, velvet beans, peanuts, and certain varieties of cowpeas, of which the Iron and Brabham are perhaps the best known.

By perfectly clean tillage to keep down all vegetation or a proper cropping system for at least two seasons, land infested with nematodes can be brought into a suitable degree of freedom from them to render it fit for planting to strawberries. Then, by taking every precaution against reinfestation from setting infested plants, or from tools that have been in infested soil, or from other sources, land once freed may be expected to remain so for a considerable period of time.

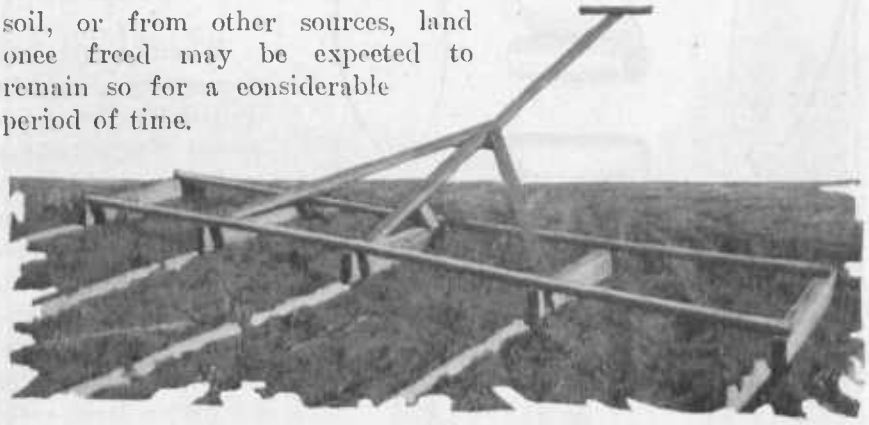

FIG. 8.—A homemade marker for use in indicating the position where the rows of plants are to run. This marker is drawn by hand.

Preparation for irrigation.—Where the land is to be irrigated it must be leveled or contoured, and furrows must be provided to convey the water through the fields. Unless the field is level or the slope even, water will collect in depressions, so that some plants will be flooded, while others will receive too little water. In most sections the berries are planted on raised beds, which vary in width from slightly more than a foot to several feet. If the water percolates through the soil rapidly so that the entire bed is moistened readily, wide beds may be used, while if the soil is of such a type that water percolates through it with difficulty, the beds must be made much narrower. They should be raised above the furrows from 2 to 12 inches, according to the necessity for drainage.

By plowing, grading, and harrowing, the field should be put into such condition that it can be easily irrigated and thoroughly drained, and the tilth should be similar to that desired for a vegetable garden. Figure 3 shows the character of the beds on which

the plants are set and the furrows between the beds as they appear in different regions.

In many localities very shallow furrows are used for distributing irrigation water, and the furrows are made after the plants have been set. Figure 4, *A*, shows a field set by this method. Where this method is used the preparation of the soil will include such grading and leveling as are necessary to provide for ease in irrigation when the furrows are finally made.

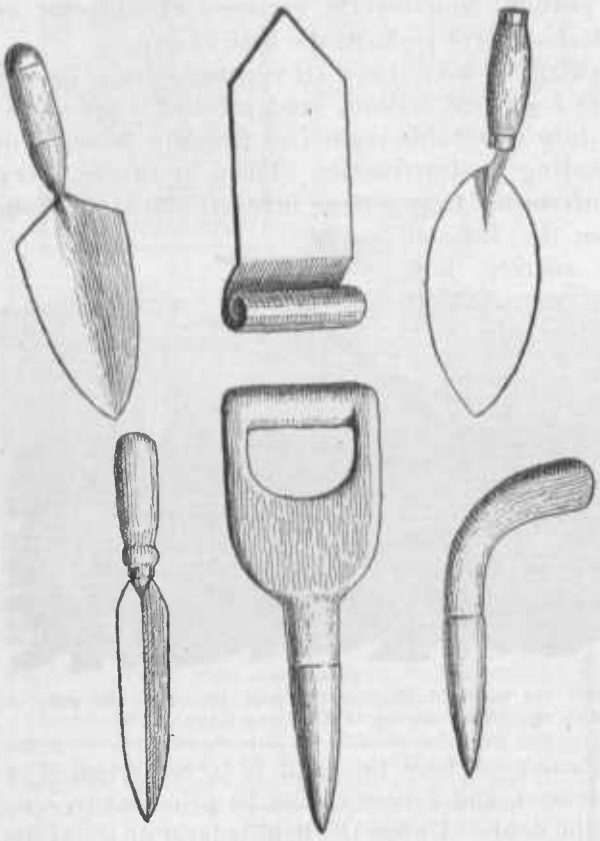

FIG. 9.—Types of trowels and dibbles used in setting strawberry plants.

HOW TO OBTAIN PLANTS.

Whether plants for setting should be raised locally or secured from some other section depends chiefly on whether or not nematodes infest the soil. The growers in California regularly obtain their supplies of plants from eastern or northwestern nurseries. As the nematode is seldom serious in localities having severe winters, it is usually safer to secure plants from nurseries located in regions where the ground freezes at least moderately.

Strawberries are propagated commercially by the use of runner plants only, and where nematodes and other diseases are not serious, each grower can raise his own stock easily from his bearing plantation. The younger plants along the sides of the matted rows can be used for this purpose. These plants develop and take root during the summer and autumn, and are more likely to start a vigorous growth after transplanting than the older plants which are ready to start fruit bearing. In digging plants, the roots of those left should be disturbed as little as possible.

TIME OF PLANTING.

In most localities the season of planting will depend upon the period of greatest rainfall, although it is not necessary to rely so largely on rainfall where irrigation is used. As the period of rainfall is usually in the winter in California, Oregon, and Washington, growers in those States generally set their plants during the winter or spring, according to the conditions in the different regions. In most parts of California late fall and early winter are preferred, for if the plants are set in November or December and make a good growth during the winter considerable fruit may be harvested during the following summer. On sandy soils the plants can be set at

FIG. 10.—Superb everbearing strawberries grown as an intercrop in an apple orchard. (Photographed at Jerome, Idaho, July 27, 1916.)

almost any time during the winter, but on heavy soils the setting should be done just after the first rains. If the heavy rains occur before the planting is finished, however, the soil under most California conditions is in such poor condition for working that growers generally prefer to wait until early spring to set the remainder. In western Oregon and Washington, and in other northern parts of the irrigated regions, early-spring planting is preferred by most growers, for the cold is likely to injure autumn-set plants which are not fully established. In western Texas, the plants are often set in early autumn and a crop harvested the following spring.

PLANTING AND TRAINING SYSTEMS.

Two general systems of planting and training strawberries are used—the hill system and the matted-row system.

Hill system.—When they are to be grown under the hill system, strawberry plants are commonly set 12 to 30 inches apart in the row, and all runners are removed as they appear. Figure 5, *A*, shows a field trained to this system, which is used quite largely throughout the irrigated regions of the United States as well as in the South Atlantic and Gulf Coast States and under overhead-spray irrigation in the Northwestern States.

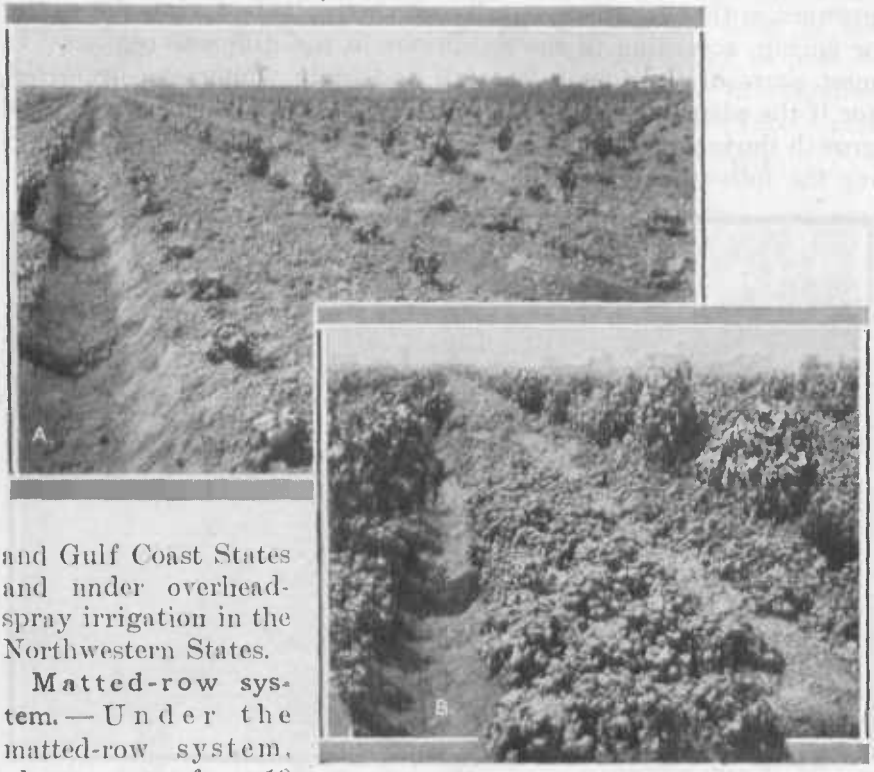

FIG. 11.—*A*, Strawberries interplanted in a vineyard. These plants were set about 18 inches apart along the edge of the furrows, which are 8 feet apart. (Photographed at Florin, Calif., August 25, 1916.) *B*, Another picture of strawberries interplanted in a vineyard. The plants were set when the grapevines were planted and furnish an income until the vines begin to bear. Four crops of berries are usually secured before they are plowed up. The furrows are 8 feet apart, and the strawberry plants were spaced by hand on the beds. (Photographed at Florin, Calif., August 25, 1916.)

Matted-row system.—Under the matted-row system, plants are set from 18 inches to 4 feet apart in rows, and part or all of the runners which appear are allowed to root. Perhaps the most common practice in irrigated regions is to allow each plant to make a definite number of new runner plants. These plants are spaced from 6 to 8 inches apart and all others removed as fast as they develop. Spacing is done by covering the tips of the runners with earth as soon as they begin to enlarge. Figures 5, *B*, and 11, *B*, show fields of strawberries grown in accordance with this system.

THE PLANTING SYSTEM TO ADOPT.

Both the hill and the spaced matted-row systems are used extensively in irrigated regions. The particular system to use will depend on the local conditions. Where the soil is heavy and rather impervious to water, narrow beds must be made and the hill system should be adopted. In cases where the soil is penetrated readily to some distance by irrigation water, the beds may be wider and the spaced matted-row system may be used. One advantage of the matted row is that the beds are wider and there are fewer furrows to care for. Both systems, however, are dependent upon intensive cultivation for the best results, and if sufficient labor is available, one or

FIG. 12.—Soon after the strawberry crop has been harvested, the tops of the plants are cut off with a hoe, sickle, or scythe. The foliage on the plants at the right has been cut. (Photographed at Vashon, Wash., August 7, 1916.)

the other should be used. Where the labor supply is not abundant and where it is not desirable to use the most intensive methods a matted row in which the plants are not spaced may be used. This system, however, is rarely adopted in irrigated regions.

In the Los Angeles region of California, where the hill system is used, the plants are set at intervals of 1 foot in rows 2 feet apart. In light soils in this same region the plants may be set 4 feet apart in rows 3 feet apart. Runner plants are so spaced that two rows 12 inches apart with plants at intervals of 6 to 12 inches finally occupy each bed, as shown in figure 3, *C*.

About Santa Rosa, Calif., and in the counties just south of San Francisco, the plants may be set in accordance with the hill system 18 inches apart in rows 2 feet apart, as shown in figure 3, *D*, or

1 foot apart in rows 3½ feet apart, as shown in figure 4, *B*, or 8 inches apart in double rows 14 inches apart with an alley 28 inches wide between the beds, as shown in figure 5, *A*. The spaced matted-row system is also used in this section, as shown in figure 5, *B*. The beds are 2 to 2½ feet wide and the furrows 2 feet wide. The usual custom is to set two rows of plants on each bed next to the edges. The runner plants are then spaced 6 to 8 inches apart as they develop.

In the Sacramento region of California the spaced matted-row system is commonly used. The beds are made 8 feet from center to center. The plants are set about 18 inches apart along both edges of the furrows, figure 5, *B*, and a spaced matted row is formed from the runner plants.

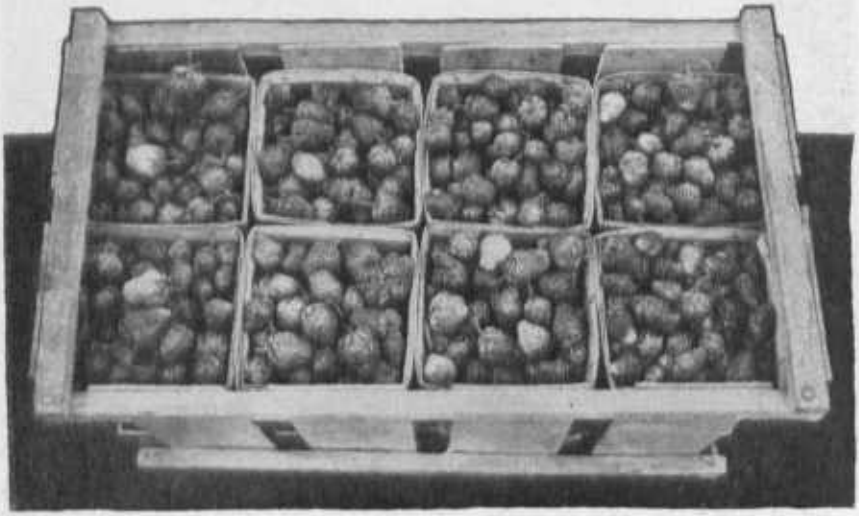

FIG. 13.—A folding ventilated 24-quart crate containing Jucunda strawberries. (Photographed at Steamboat Springs, Colo., July 20, 1916.)

In the Hood River region of Oregon and in the White Salmon region of Washington the hill system illustrated in figure 4, *A*, is used almost exclusively. The plants are set 12 to 18 inches apart in rows 30 to 32 inches distant.

In other parts of the area to which this bulletin applies, both the hill and the matted-row systems are used, but the plans of setting and training for the most part are similar to those that are here illustrated and described.

NUMBER OF PLANTS PER ACRE.

Table I shows the number of plants needed to set an acre of ground when the plants are spaced in accordance with one of the planting systems commonly used.

TABLE I.—*Number of strawberry plants required to set an acre of ground when spaced different distances apart.*

Distance apart.	Plants to the acre.	Distance apart.	Plants to the acre.
2 feet by 1 foot	21,780	2½ feet by 1½ feet	11,616
2 feet by 1½ feet	14,520	3 feet by 2 feet	7,260
3 feet by 1 foot	14,520	3 feet by 3 feet	4,840
3½ feet by 1 foot	12,446	3 feet by 4 feet	3,630

Where there is little danger of loss of plants from any cause, only the number indicated will be needed. If such danger exists, a somewhat larger number should be secured in order to insure a full stand, as the expense of irrigating and caring for a field which has many blank spaces will be out of proportion to the value of the crop obtained.

CARE OF PLANTS.

When the plants are received from a nursery, they are usually tied in bundles, as shown in figure 6, *A*. Good plants usually have bright, light-colored root systems. When grown on very dark soil, however, they may be brown or yellowish in color. If the plants are at all dry upon arrival, the roots should be soaked in water for a few hours before planting or heeling in. If they can not be set at once, the bundles should be opened and the plants separated and heeled in, as shown in figure 6, *B*. The soil packed about the roots of the plants should be thoroughly moistened.

The plants to be set should be protected from the sun and from drying winds while they are being distributed in the field, either by means of burlap, old sacks, or in some other effective way. An old fertilizer sack may be used for protecting the plants while dropping them (fig. 7, *C*).

SETTING THE PLANTS.

When furrows and beds are made in preparing the soil, they will show approximately the rows on which the plants are to be set. Care should be taken, however, to have the rows straight, and the exact place for the setting of each individual plant may be indicated by the use of a marker similar to that shown in figure 8.

If the soil is very mellow, a place for the roots may be made with the hand, but in heavier soil a dibble or trowel (fig. 9) or the tools known as punch and tongs (fig. 7, *A*) may be used. One accustomed to their use can set 10,000 plants in 8 hours, and experts can set a much larger number.

Perhaps the most important points in setting plants are to place them at the right depth and thoroughly to firm the soil about the

roots after they are set. If the plants are set too high or the soil is not sufficiently firm, they will dry out and die, while if they are set too low and the crown is covered with soil, the plants may rot. Figure 7, *B*, shows plants set too shallow, too deep, and at the proper depth.

CARE AFTER PLANTING.

Where the plants are set in early spring, flower stems frequently appear in a short time. Unless the plants are thoroughly established in the soil these should be removed, as the production of fruit is too great a strain on plants not fully established. When a large number of runner plants are needed, the flower stems should also be removed, as experiments have shown that this practice will increase the number of runner plants that are made.

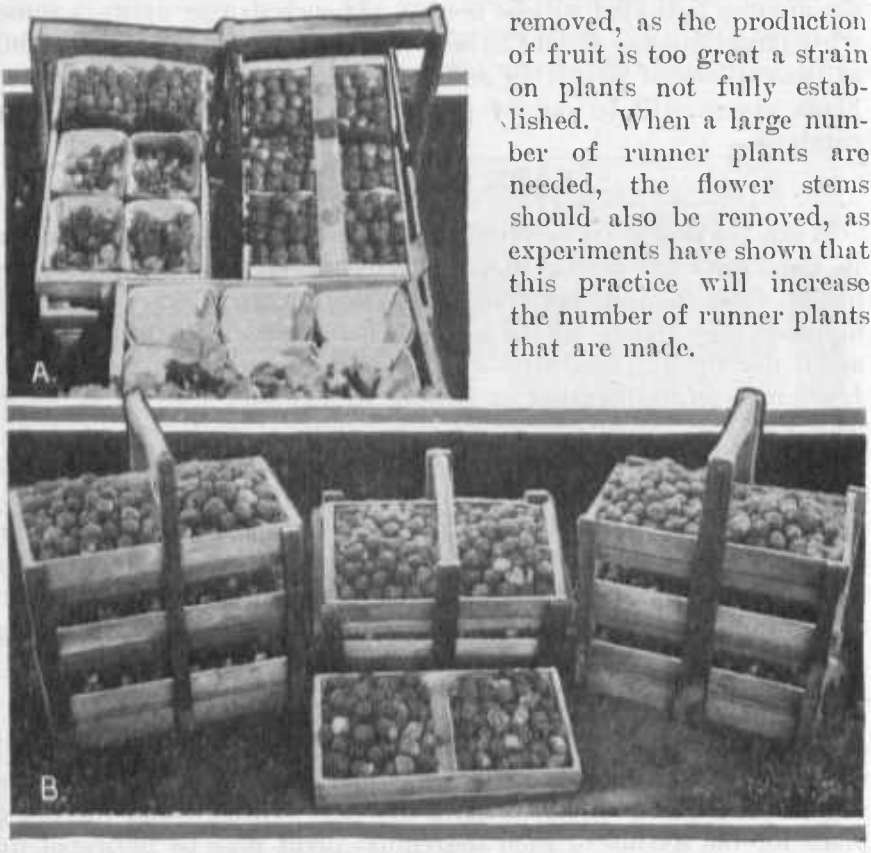

FIG. 14.—*A*, Strawberry carriers and trays used in picking. The tray that is filled contains six 12-ounce baskets of strawberries; one is partially filled and one is empty. (Photographed at Santa Clara, Calif., September 4, 1916.) *B*, Carriers used in taking the trays from the field to the packing house or chest. (Photographed at Santa Rosa, Calif., August 31, 1916.)

When all the runners that develop are allowed to root without any restrictions, too many plants form in the matted rows, and some means should be taken to thin them. Sometimes roller cutters are attached to cultivators and all runners extending into the furrows are removed by them. A distance of at least 6 inches should be

maintained between plants in matted rows, and when necessary, the plants should be thinned with a hoe or by hand in order to prevent overcrowding.

When the plants in the matted row are spaced, the strongest runners are selected. As soon as the tip of a runner has enlarged and a leaf appears, it is covered with soil. Each runner is thus made to take root at a predetermined distance from the parent plant and from adjoining runner plants. Sometimes a large number of runner plants are made to root, either in distinct rows, as shown in figure 3, *C*, or at a distance of about 7 or 8 inches from each other. (See figs. 3 (*A* and *B*), 4 (*B*), and 11 (*B*).) All runners

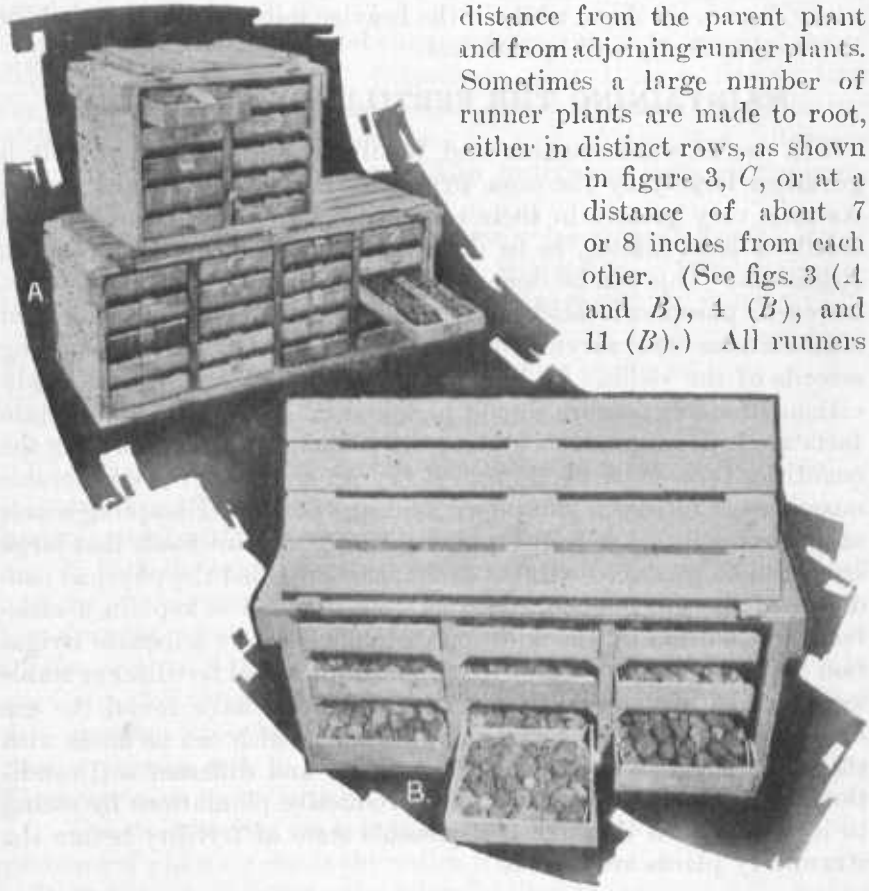

FIG. 15.—*A*, A standard chest containing 20 trays, each holding six 12-ounce baskets of strawberries, with a half chest shown above. (Photographed at Watsonville, Calif., September 6, 1916.) *B*, A chest of trays, each of which holds two 2-pound baskets of strawberries. (Photographed at Santa Rosa, Calif., August 31, 1916.)

except those used are removed by a hoe, knife, or in some other way.

Purposes of tillage.—Tillage is practiced to conserve moisture, to aerate the soil, and to keep down weeds. It should begin soon after the plants are set, and should be continued during the growing season. As soon as possible after each irrigation, the irrigation furrows should be cultivated. This leaves a dust mulch on the surface which

conserves moisture and helps keep the soil in good condition. If the furrows are not cultivated, the soil may become water-logged and may shrink on drying so that large cracks appear. (See fig. 5, *B*.) These cracks not only increase the loss of water by evaporation, but may even break the roots of the plants. One-horse cultivators are usually run through the furrows, and hand hoes or rakes used on the beds. In light soils, a horse cultivator may be used as often as once every four to six days, while in the heavier soils, once every week or two weeks usually will be sufficient.

MAINTAINING THE FERTILITY OF THE SOIL.

The use of stable manure and fertilizers on strawberry fields is governed largely by the same principles that apply to other crops. As soils vary greatly in their composition, the use of fertilizers is chiefly a local matter, to be determined by each man for his own conditions. This can be done by applying the different plant foods, nitrogen, phosphoric acid, and potash, separately and in different combinations and varying quantities to small plats, and keeping records of the yields. In like manner, the effect of different applications of stable manure should be tested on small plats. If certain facts are kept in mind, such plats will be helpful in determining the quantities to use. A good crop of berries will remove considerable quantities of nitrogen, phosphoric acid, and potash. Excepting coarse sand, most soils are so well supplied with these plant foods that large crops can be produced without fertilizers, provided the physical condition of the soil is good. If, therefore, the soil is kept in a satisfactory condition by the addition of humus and by adequate irrigation and tillage, many soils will need no commercial fertilizer or stable manure. In many localities, however, growers have found the use of fertilizers profitable, but the applications which can be made with the greatest gain vary with different soils and different soil conditions. Much can be done to insure productive plantations by seeing to it that the soil is in the best possible state of fertility before the strawberry plants are set out.

IRRIGATING STRAWBERRIES.

Strawberries must have an ample supply of moisture, not only during the season when they are bearing fruit, but also throughout the growing season. As the root system is shallow, the surface soil must be kept moist and the irrigations must be more frequent than for many plants whose roots penetrate the soil deeply, the number of irrigations, however, will depend largely on the character and frequency of the tillage used in conserving moisture and on the type and condition of the soil. If the furrows are thoroughly cultivated as soon as the moisture conditions permit after each irrigation, the

number of applications of water can be materially reduced as compared with the number required when cultivation is neglected. In the lighter soils during the bearing season, the fields may be irrigated as often as every 4 to 6 days, and in heavy soils every week or two. During the months when the plants are not fruiting, irrigation need not be so frequent as when the crop is developing, only enough water to keep them in a thrifty growing condition being necessary.

During the fruiting period the usual practice is to irrigate immediately after each picking. Sometimes, when there is danger that the water in the furrows may not be absorbed before the following picking, the field may be covered by two applications, alternate furrows being irrigated in turn. The pickers can then use the unirrigated furrows when at work.

In California the plants produce fruit for several months, from late in March or early in April until September or October; sometimes even until December. In that State, therefore, water will be needed for bearing plantations through a much longer season than in States where only an early summer crop is produced.

THE STRAWBERRY AS AN INTERCROP.

The strawberry is grown quite largely as an intercrop in orchards in most irrigated regions. In sections where the water supply is under control of the grower and a sufficient quantity can be used to supply both the trees which are being grown for the permanent crop and the strawberries, this plan is practicable. If properly managed, the strawberries should pay a large part of the expense for the care of the orchard until it comes into bearing. Figures 5, *B*, and 10 show strawberries as an intercrop in prune and apple orchards. In a few locations strawberries are used as an intercrop in cherry and pear orchards, and to a slight extent in orchards of other fruits. They are also quite largely used in vineyards, as shown in figure 11. The strawberries are left until they become unproductive or the permanent planting needs the entire space.

In nonirrigated regions the interplanting of orchards with strawberries is inadvisable except under well-considered restrictions.

DURATION OF A PLANTATION.

The length of time that a strawberry plantation is kept depends chiefly upon its productiveness. If the humus content is ample, so that the soil is in good tilth, and if diseases and insects are not serious, the plantation may be fruited for several years. In California the crop is usually largest the second year. Large crops may also be secured in some regions in the third and fourth years, after which the plantations generally are discontinued. In other

States the plantations are usually continued for four seasons, although where the strawberry root weevil is common they may become unprofitable after one or two crops have been produced.

RENEWING THE PLANTATION.

MOWING THE FOLIAGE.

As soon as the crop has been harvested the foliage frequently is cut off at the surface of the ground. Scythes, sickles, or hoes are used for this purpose. The new growth starts out quickly, and the later care of such fields involves less labor than otherwise would be necessary. Figure 12 shows a field in which the foliage on some of the plants has been cut.

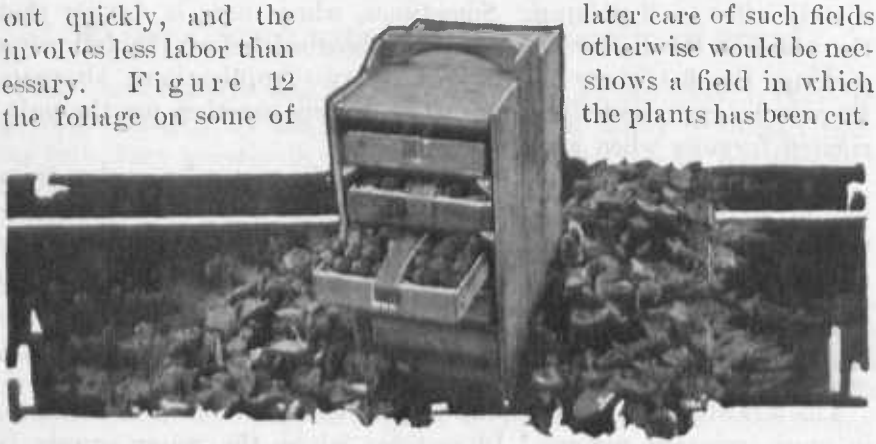

FIG. 16.—A hand carrier of trays of strawberries. These covered carriers protect the berries from the sun while they are in the field. (Photographed at Watsonville, Calif., September 6, 1916.)

THINNING THE PLANTS.

Where the matted-row system is used, the plants are generally thinned immediately after the foliage has been cut. In some cases, the rows are narrowed by plowing up a part of each side, and the remaining plants are thinned with a hoe. In other cases two-thirds of the width of each row may be plowed up, including the plants which have recently produced a crop. Later in the season runner plants which develop are allowed to replace those removed. Thus, the plants which have become weakened by fruit production are replaced by new and vigorous plants for the next season's crop.

HARVESTING AND SHIPPING.

The harvesting season varies greatly in the different parts of the irrigated regions, being affected both by the climate and by the variety. In southern California, the Brandywine variety begins to ripen in March, and may continue to fruit until December. In that same region the Klondike produces a heavy crop during March, April, and May, but yields little or nothing thereafter until the next season. The principal varieties grown in central California usually produce

continuously from April throughout the summer and until September or October. In Oregon most varieties produce fruit only during the early summer months. In some of the other regions the harvesting season varies as widely as it does along the Pacific coast.

The main shipping season in all regions is during the early summer, except in the Steamboat Springs district of Colorado, where the season is during July and August. Most of the berries ripening in the summer and autumn in California are shipped to local markets or to canneries.

When intended for the general market, such packages as those shown in figures 13 and 14 are used. Figure 13 shows a folding ventilated 24-quart crate. In Oregon and Washington, the 24-pint crate is in use, while in certain parts of California 20 and 30 pint crates are employed. The chests used in the districts near San Francisco are shown in figure 15. Figures 14 and 16 show the various types of carriers used in picking. The 12-ounce splint baskets shown in figure 15, *B*, are packed in the field by the pickers. These baskets are placed in trays that fit into the chests shown in figure 15, *A*. Two-pound baskets like those shown in figures 14 and 15, are also used. A carrier used by pickers to hold the trays and baskets is shown in figure 16. The carriers in which the trays are taken to the packing sheds or to the chests are shown in figures 14 (*B*) and 16. Carriers used by pickers in southern California are shown in figure 16.

In one locality near Los Angeles, and to a slight extent elsewhere, pony refrigerators are used. Each of these contains compartments for both ice and berries. They are commonly shipped by express to special markets.

VARIETIES.

In the whole semiarid region to which this bulletin applies, only a very few varieties are grown extensively at the present time. These varieties are listed in Table II.

TABLE II.—*List of strawberry varieties arranged by States and sections.*

[KEY.—An asterisk (*) before a name indicates that the variety is recommended for commercial planting. Varieties without an asterisk are grown more or less in the States and sections listed, but are not considered so desirable for commercial planting as the others.]

State and section.	Varieties.	Remarks.
ARIZONA.		
Throughout the State	*Arizona	
	*Klondike	
	St. Louis	
CALIFORNIA.		
Fresno	*Marshall	Fruits throughout the summer.
	Brandywine	
Los Angeles	*Brandywine	
	*Klondike	Spring crop early.
	Excelsior	
	Nich Ohmer	

TABLE II.—*List of strawberry varieties arranged by States and sections*—Con.

State and section.	Varieties.	Remarks.
CALIFORNIA—continued.		
Sacramento	*Dollar	Best shipping and late season sort.
	Jessie	For early season.
	*Marshall	Replacing Jessie.
San Francisco	....do	
	*Oregon	
	*Nich Ohmer	
	Melinda	For canning.
Throughout the State:		
North of Fresno	*Marshall	
	*Oregon	
	*Dollar	
	*Nich Ohmer	
	Longworth	Light yielder.
South of Fresno	*Brandywine	For dessert purposes.
	*Klondike	For shipping.
COLORADO.		
Loveland and Denver	*Dunlap	For early season.
	*Jucunda	For late season.
Steamboat Springs	....do	For late season.
Throughout the State	*Dunlap	For early season.
	*Jucunda	For late season.
IDAHO.		
Throughout the State	*Superb	Everbearers.
	Progressive	Everbearers.
	Clark	For shipping.
	*Glen Mary	For local market.
	Brandywine	For local market.
	Belt (*William Belt*)	For local market.
	Marshall	For local market.
MONTANA.		
Throughout the State	*Dunlap	
NEVADA.		
Throughout the State		Utah and California sorts should be tried.
NEW MEXICO.		
Throughout the State		Colorado and Arizona varieties should be tried.
OREGON.		
Hood River	*Clark	
Throughout the State	*Gold Dollar	For early local market.
	*Magoon	For midseason local market.
	*Marshall	For midseason local market.
	*Clark	For canning and shipping.
	*Wilson	For rich soils.
	*Oregon	For local market and home use. Has long fruiting season.
	Superb	An everbearer.
WASHINGTON.		
White Salmon	*Clark	
Puget Sound	*Marshall	For general use.
	*Clark	For shipping and canning.
	Magoon	
	Gold Dollar	
	Oregon	
	*Wilson	For canning.
WYOMING.		
Throughout the State	*Dunlap	
	Bederwood	

In the western parts of North Dakota, South Dakota, Kansas, Nebraska, and Oklahoma very few strawberries are raised, but the Dunlap is perhaps as promising as any variety wherever the condi-

tions offer any promise of success. In western Texas the Klondike is commonly grown.

NEW SORTS should be tested carefully before large areas are planted to them.[1] Just as the varieties grown at present have supplanted those formerly grown because they are superior in some important characteristics, so other varieties will probably be developed which in turn will supplant those now popular.

INSECTS AND DISEASES.

The relation of white grubs and nematodes to the growing of strawberries has been mentioned, and the common methods of avoiding serious loss from them have been given in the discussion of the preparation of the soil for planting. The strawberry root weevil, and possibly other insects, may cause the grower some trouble in the regions covered by this bulletin. Certain diseases may also occur.

The control of insects and diseases calls for more extended and detailed consideration than can be given in this bulletin. The grower should familarize himself so far as possible with those that are likely to occur in his locality, and thus be able to recognize and combat them as soon as they are discovered. Information relating to strawberry insects and diseases may be found in many bulletins of the State agricultural experiment stations and in publications issued by the United States Department of Agriculture. Growers should be in close touch with the experiment stations in their own States, and upon the discovery of any insect or disease with which they are unfamiliar they should send specimens at once there or to the United States Department of Agriculture for examination. Early recognition of an insect or disease newly discovered in a community may make possible the application of control measures which will prevent a serious outbreak that otherwise would be a menace to the entire community.

USES OF THE STRAWBERRY.

Many million dollars' worth of strawberry products are manufactured each year. Among the more important of these products are preserves, jams, conserves, essences for flavoring candies and for use as flavoring extracts, sirup for soda fountains, and crushed fruit for flavoring ice cream and sauces. Large quantities of strawberries

[1] Farmers' Bulletin 1043, entitled, "Strawberry Varieties in the United States," which can be obtained free of charge upon application to the Secretary of Agriculture, showing the varieties grown in all parts of the United States, will prove suggestive to those interested in testing varieties.

are also canned. The varieties commonly used for these purposes are deep red to the center, acid with a strong strawberry flavor, and firm fleshed, so that they will not break to pieces in cooking. Among the best varieties for such purposes are the Klondike, Wilson, and Clark. Where these sorts are not well adapted for culture the Parsons, Superior, Marshall, Warfield, Dunlap, Gandy, Joe, Missionary, and others are grown.

Many factories for utilizing the strawberry have been erected in the large producing areas. Other factories to which the fruit is shipped are located in the cities. The managers of these factories have found that the strawberry is in the best condition for use if picked while very firm, even before it is fully ripe, and made up the same day. The factories located in the producing areas, therefore, have an opportunity to make the finest product. In utilizing strawberries in the home or for the market the experience of these concerns in selecting certain varieties and using firm berries the same day they are picked should be followed. The directions for making strawberry products given on the following pages are based largely on the experience of commercial concerns.

CANNING.

Sort out defective berries; wash and hull; pack the jars level full with sound, firm berries not fully ripe; fill the jar with a sirup of 30° Balling density made by boiling 3 pounds 9 ounces (8 cups) of sugar in 1 gallon (16 cups) of water until the sugar is dissolved, and then process[1] pint jars 10 minutes and quart jars 12 minutes. To make an especially fine product in the home, heat the smaller and softer berries and strain the juice from them, using this juice with sugar to make a sirup. Pour this sirup boiling hot over the berries in jars and process as directed above. Instead of processing 12 minutes in the usual way, the cans may be placed in a kettle of boiling water and the kettle covered tightly. It is at once removed from the stove and allowed to cool before the jars are removed from the water. Commercial canners wash the berries after hulling instead of before hulling and use sirups varying from 30° to 60° density; for pie stock they often can strawberries without the use of sugar.

PRESERVING.

Recipe No. 1.—Sort out defective berries; wash and hull. Make a sirup by adding 35 ounces (5 cups) of sugar to 1 cup of water and bring to the boiling point. Add 2¾ pounds (almost 2 quarts) of

[1] To process, place the jars in a water bath on a rack which allows circulation of water beneath them. Have the water about the same temperature as the contents of the jars. The water should be about an inch over the tops of the jars. Have the covers on the jars but not tightened. Count the time when the water begins to boil and keep boiling steadily for the time required; then remove the jars promptly and tighten the seal.

berries to this hot sirup; boil until a candy or chemical thermometer registers 222° F., or until the sirup is thick. Pack the jars level full of berries and fill with the sirup. Process pint jars at simmering (188° F.) for 30 minutes.

Recipe No. 2.—Sort out defective berries and wash and hull the sound ones. Add three-fourths pound of sugar to each pound of berries; let them stand over night in a warm room; drain off the juice and reduce by boiling until it thickens into a sirup; pack the fruit in jars and pour the hot sirup over it; let it stand for 24 hours; heat slowly to the boiling point in a water bath; remove from the water and seal.

Recipe No. 3.—Sort out defective berries; wash and hull. Heat the smaller and softer berries and strain the juice from them. To 1½ pounds (almost 3½ cups) of sugar add 1 cup of the berry juice; bring to the boiling point; then cool. When cool add the berries, a few at a time; heat slowly to the boiling point and cook until the berries are bright and transparent (106° C. or 223° F.); cool and pack in cold sterilized jars. Process pint jars at simmering for 30 minutes.

SUN PRESERVING.

Recipe No. 1.—Select sound, ripe berries; wash and hull. Prepare a sirup by adding three-fourths pound (1⅞ cups) of sugar to each pound of berries and let them stand for several hours in a warm room to extract the juice. Then drain off the juice and heat it. When it boils add the berries and cook for five minutes. Remove from the fire, spread in shallow platters, cover with glass, and put in sun while hot. Leave in the sun until the sirup thickens; then put in sterilized jars and cover with hot paraffin.

Recipe No. 2.—Select sound, ripe berries; wash and hull. Use three-fourths pound (1⅞ cups) of sugar to 1 pound of berries; put the berries in a kettle in a warm place until the sugar is dissolved. Bring to a boil, remove from the fire, spread on shallow platters, cover with glass, and put in the sun while hot; leave in the sun until the sirup thickens; then put in sterilized jars and cover with hot paraffin.

STRAWBERRY JAM.

Sort out defective berries; wash and hull. Mash thoroughly and add three-fourths pound (1⅞ cups) of sugar to each pound of berries; cook slowly for 20 minutes or until the jam is of the desired thickness. Pack in sterilized jars; cover with paraffin or seal after processing for five minutes in a hot-water bath.

COMBINATIONS WITH OTHER FRUITS.

In making preserves and jams, strawberries are often combined with other fruits. Such products are preferred by many to those

made of strawberries alone. Among the combinations considered most desirable are strawberry-raspberry, strawberry-pineapple, and strawberry-rhubarb preserves and strawberry-currant and strawberry-gooseberry jams. Although these fruits may be combined in any proportion, the following procedure will be found desirable.

Stawberry-raspberry preserves.—Crush, heat, and extract the juice from raspberries; use 1 cup of raspberry juice and 2¼ cups (almost 1 pound) of sugar for each quart of sound hulled strawberries. Proceed as for strawberry preserves.

Strawberry-rhubarb preserves.—Use 1 quart of chopped rhubarb and 1¾ pounds (4 cups) of sugar to one-third quart of strawberries. Proceed as for strawberry preserves.

Strawberry-pineapple preserves.—Use 1 pound of grated or chopped pineapple, 2 pounds of strawberries, and 2¼ pounds (5 cups) of sugar. Bring the pineapple and sugar slowly to the boiling point, and boil for about 10 minutes; then add the strawberries and cook slowly till thick; put in sterilized jars and seal.

Strawberry-currant jam.—Use three-fourths pound (1⅝ cups) of sugar and 1 pint of currant juice to 4 pounds (about 2⅔ quarts) of strawberries. Proceed as for strawberry jam.

Strawberry-gooseberry jam.—Use two cups of gooseberry pulp and 4½ cups of sugar to 2 pounds of strawberries. Proceed as for strawberry jam.

Strawberry juice.—Strawberry juice is a refreshing beverage, especially when combined with other fruit juices. One of the best combinations is made by the addition of the juice of one lemon to each pint of strawberry juice. This must be sweetened and diluted according to taste. The strawberry juice is prepared by heating the strawberries almost, but not quite, to the boiling point and at once straining out the juice. Strawberry juice will not keep its flavor or color for long periods unless stored at a low temperature.

COLD STORAGE.

First method.—When the preservation of the fresh-fruit flavor is desirable the following method may be used for packing small quantities of strawberries for use when they are not in season. Select sound, ripe berries; wash and hull. Use a tin of convenient size to which a tight cover can be fitted. To each 10 pounds of fruit use one cup of sugar; fill the cans with sugar and berries; put on the tops and cover their edges with the adhesive tape used in sealing packages; put in freezing cold storage and keep frozen until wanted. This product can be used for shortcakes, etc., by restaurants and hotels and for crushed fruit at soda fountains and by ice-cream manufacturers.

Second method.—The large manufacturers of the crushed fruits and sirups used by the soda-fountain and ice-cream trade prepare their product as it is needed at any time during the year from uncooked berries which are kept in barrels in cold storage preserved in the following manner: The berries are hulled and sorted and then washed. The washing is done by running the berries on a belt through a tank of water; then over another belt, where they are slowly turned and sprayed with water. The berries drop into pans and are weighed. To each pound of berries sugar is added, varying from ½ to 1 pound. Usually, however, the proportion is ½ pound of sugar to 1 pound of fruit. The proper proportions to use will depend upon the variety, the ripeness of the fruit, the moisture conditions, and the way in which the product is to be used. Heavy water-tight barrels holding about 375 pounds of the mixture of berries and sugar are used. Before use they are carefully examined and coated on the inside with paraffin, which is applied hot with a paintbrush. New barrels may need special treatment to prevent the berries from absorbing a woody taste. The sugar and berries are put in alternate layers and mixed by machine or by hand. As soon as the barrels are headed, they are shipped in a refrigerator car to a cold-storage warehouse, where they are held at a temperature of 30° F. or lower. Several thousand barrels of strawberries are put up in this manner every year.

After washing, the berries are sometimes dropped into a mixing tank, where the sugar and berries are thoroughly mixed by constant stirring. This tank is surrounded with ice water, in order to cool the fruit before it goes into the barrels.

If equal weights of sugar and berries are used, the barrels of fruit may be stored at a temperature of 34° to 36° F., but if the fruit is to be held for long periods the flavor is best preserved at a lower temperature.